The CRUSHED STONE JOURNAL

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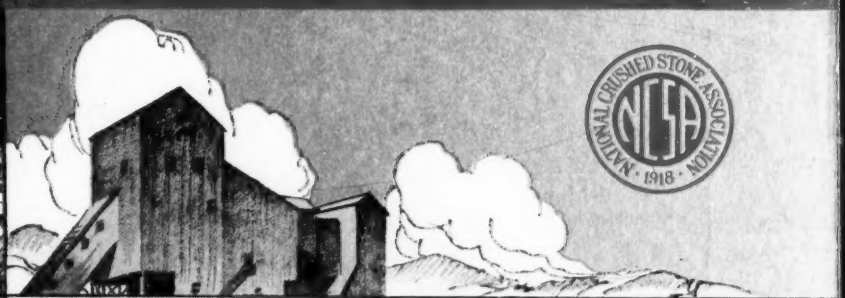

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National Crushed Stone Association, Inc.

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BULLETIN No. 1

The Bulking of Sand and Its Effect on Concrete

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BULLETIN No. 3

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"Retreading" Our Highways

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The Crushed Stone Journal

Official Publication of the NATIONAL CRUSHED STONE ASSOCIATION

J. R. BOYD, Editor

Contents

Silver Anniversary Convention

OUR NEXT ANNUAL CONVENTION marks the 25th Anniversary of the establishment of the National Crushed Stone Association—an event which the years have proved has been of vital and outstanding significance to the crushed stone industry.

Plans are already being formulated to appropriately celebrate this historic occasion.

A most thrilling and inspiring experience awaits you at our Silver Anniversary Convention. It is none too early to make your plans now to attend.

THE CRUSHED STONE JOURNAL

WASHINGTON, D. C.

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National Defense and the WPA Construction Program[1]

By PERRY A. FELLOWS

Chief Engineer, Work Projects Administration, Federal Works Agency, Washington, D. C.

• **Because of the important place occupied by WPA in the defense construction program the following observations by Mr. Fellows should be decidedly interesting, particularly in regard to WPA production of commercial materials.**

NATIONAL defense means more than turning out guns and men to use them. It means coordinating all our energies and all our resources in the task of strengthening the nation. One of the things that we must do is provide the facilities that our armed forces need in order to function efficiently—such facilities as air fields, military training centers, and strategic roads. And it is equally important for us to build up the health and morale of all our people, so as to give real substance and meaning to the defense of democracy.

I am not going to attempt to cover the broad field of national defense in my talk to you today. I am going to talk about just one part of the defense program—the part that is being contributed by the Work Projects Administration.

Every governmental agency today is making whatever contribution it can to our national defense; and the WPA's contribution is not inconsiderable. For the WPA is not only helping to provide facilities for the Army and Navy but also, by giving work and wages to the unemployed, it is helping to strengthen our population where strengthening is most needed.

A program of public works, in order to be successful, must have the whole-hearted cooperation of Federal, State, and local governmental agencies. For upon such cooperation depend the speed and efficiency with which public projects can be undertaken and carried through to completion. Cooperation in planning and cooperation in the actual work are both necessary.

The WPA has had five and one-half years of valuable experience in cooperating with State and local governments, and it is therefore in a good position to operate work projects that are of value to our national defense. As a matter of fact, the WPA has already done a great deal of defense work in the past. It is familiar with that kind of work. In order to play its part in our national defense, the WPA has not had to establish a new program; it has simply had to concentrate on those of its projects that are of military and naval importance.

The defense work of the WPA falls roughly into two categories. The first of these includes projects that are sponsored by such Federal agencies as the War and Navy Departments, and the second includes projects of military value that are sponsored by States, counties, municipalities, and by the public agencies of these political subdivisions.

Federally sponsored projects may be operated either by the WPA or by the sponsoring agency itself

[1] Presented at the Twenty-Fourth Annual Convention of the National Crushed Stone Association held at the Netherland Plaza Hotel, Cincinnati, Ohio, January 20-22, 1941.

through a direct transfer of funds to it from the WPA. Relief labor is used in either case. The majority of the projects in this category are operated at military reservations and naval stations. Work of this kind has been carried on by the WPA ever since its establishment in 1935, and as a result the defense facilities of the nation are in far better condition today then they would have been without WPA assistance.

Locally sponsored defense work is equally important. This work includes the construction and improvement of airports, of strategic highways and of roads giving access to military and naval establishments. It also includes conservation and public health work.

A brief summary of the defense work already accomplished by the WPA will give some idea of the contribution which this agency can be expected to make in the future.

WPA accomplishments in five years—that is to say, up to July first, 1940—include the construction or improvement of some 13,000 buildings related to defense, most of them owned by the Army and Navy, and of 564 landing fields for aircraft. These accomplishments include work at three-fourths of all our Army posts, and 85 per cent of all American airport construction since July 1, 1935. The construction or improvement of more than 517,000 miles of roads and streets, as well as valuable work in the fields of public health and conservation, includes a great amount of secondary defense work—that is, work which has an important bearing upon the nation's preparedness, though not directly connected with defense facilities.

The defense work that the WPA is doing today is even more important than that which it has done in the past. Today, for example, the WPA is helping the Army to develop air bases, strategically located at the four corners of the country—McChord Field, near Tacoma, Washington; March Field, near Los Angeles; Westover Field, near Springfield, Massachusetts; and the McDill Field, near Tampa. Other important defense projects include work at such military training centers as Fort Dix in New Jersey, Camp Grant in Illinois, and Fort Sill in Oklahoma. Also, construction and improvement work is being done for the Navy at the Submarine Base at New Haven, Connecticut; at Pensacola Air Station in Florida; Mare Island Navy Yard, near San Francisco; the Great Lakes Naval Training Station, and many other places.

Instead of giving you my own opinion of the value of this WPA defense work, I feel that I should quote a more impartial authority—General George Marshall, Chief of Staff of the United States Army.

This is what General Marshall said (and I quote):

"In the great task of preparing for national defense, the WPA has proved itself to be an invaluable aid. Already in the field, it has been carrying out work for the Army and Navy for the last five years, and its services in this direction have been rapidly expanded. The prompt aid contributed by the WPA has given an impetus to the national defense program, of much importance at this particular time."

To this I will add one more bit of impartial testimony—that of Mr. Donald M. Nelson, Coordinator of National Defense Purchases. Said Mr. Nelson (and I quote again):

"As everybody knows, the great problem in national defense is to get things done in a hurry. Private employers, although they are eager to cooperate in the great task of national defense, often find it difficult to shift quickly from their regular tasks, to meet the requirements of the Army and Navy. It is in this situation that we have discovered the value of the WPA organization. WPA workers can be quickly turned to defense work."

These testimonies should dispel any possible doubt, I think, regarding the usefulness of the WPA contribution to our national defense program.

There are two kinds of defense work done by the WPA which are likely to become increasingly important during 1940 and which are of particular interest to you as members of the National Crushed Stone Association. I am referring to work on airports and work on roads and highways.

The development of adequate airports is a matter of primary concern to those entrusted with the responsibility of planning the defense of the nation. Not only military air bases but also civil airports are essential. Most of our student pilots first learn to fly, and then keep in practice, at civil airports. Our military pilots use civil airports as servicing points in their flights across country, and as auxiliary bases during concentrated maneuvers; and in case of invasion they would use them as auxiliary bases for actual military operations.

Essential items of work on most airport projects are grading, drainage, construction and extension of runways, runway paving, and in general all improvements to the field proper. The work must meet the specifications of the Civil Aeronautics Board in the case of civil airports and those of the War and Navy Departments in the case of military and naval

fields. Certain airports or locations for airports are considered vital to the plans of the War and Navy Departments; and the State WPA administrators and the regional Civil Aeronautics offices are in possession of this information, and projects are planned accordingly.

The defense program also calls for considerable development of the nation's network of roads and highways. New and improved roads giving access to military and naval posts, stations, and concentration areas, as well as routes within the national strategic system of highways, as determined by the War Department, are of vital importance. For some time now, the WPA has been working in close cooperation with the Public Roads Administration and with the War and Navy Departments in planning and accomplishing this work.

WPA projects for access roads are originated and planned in consultation with the appropriate Army Post Commander or Naval Commandant, with the District Engineer of the Public Roads Administration, with a representative of the State Highway Department, and with representatives of such local political subdivisions as may have jurisdiction over the roads in question. Projects for access roads, outside of military and naval establishments, must necessarily be sponsored, not by the War and Navy Departments, but by the State or local governmental agency which has competent jurisdiction. It may be possible in some cases for the Public Roads Administration to assist in financing such improvements. The problems of joint participation are worked out in the planning of the project.

Just as in the case of access roads, so also in the case of strategic highways, the location and character of the work to be done is decided in consultation with the Public Roads Administration and the various State Highway Departments. Certain ultimate standards must be met which have been recommended by the Public Roads Administration and approved by the War Department. For example, strategic highways must have a hard surface, capable of supporting a 9000-pound wheel load on pneumatic tires. They must be at least twenty feet wide; and their bridges must be four feet wider and capable of bearing a weight of fifteen tons. And there are other specifications, including maximum grades and curves and minimum vertical clearance and sight distance. The WPA contribution may work toward the accomplishment of these standards even though the immediate work may provide only partial accomplishment.

In order to expedite work on defense highways, both the WPA and the Public Roads Administration have arranged a maximum decentralization of their activities. Maps, prepared jointly by the State Highway Departments and the Public Roads Administration and based on surveys made by the latter in cooperation with the War Department, are now available to the various State WPA Administrators. And district engineers of the Public Roads Administration help to review project plans and specifications, so that units of work may be undertaken without the delays incident to submission of final plans and specifications to the Washington office of either the WPA or the Public Roads Administration.

While every project requires the preparation of plans and specifications, as well as an estimate of cost, and the submission of such documents to the State WPA Administrator for approval, in many cases the State Administrator has authority to do highway work at certain places in his State without the necessity of submitting the project in advance to the Washington office. So it may be possible for work of vital importance to commence immediately.

The kind of work that predominates in the WPA program is influenced by certain practical considerations. The WPA is a work-relief agency; it must provide as much employment as possible with its funds, and therefore it does not devote an excessive percentage of its money to non-labor costs on the average project. That is why WPA workers are usually set to widening road shoulders, clearing rights-of-way, grading, improving road beds, and installing minor drainage structures. Such work represents a larger proportion of the WPA program than the construction of large bridges or underpasses except in those cases where other agencies, either State or Federal, including the Public Roads Administration are not in a position to carry out the work alone.

It is obvious, of course that all WPA projects involve non-labor costs for materials. But the WPA has an arrangement with its project sponsors whereby the sponsors assume the chief burden of meeting the cost of materials while the WPA bears nearly all of the labor cost. Now the WPA requires the sponsors to put up funds sufficient to provide proper and adequate materials; and this often creates a financial problem for the sponsors. In their figuring they are well aware of the fact that there are certain ways of transforming material costs into labor costs. That is to say, some materials can be produced or

(*Continued on page 16*)

Contractors and National Defense[1]

By JAMES D. MARSHALL

Assistant Managing Director, The Associated General Contractors of America, Washington, D. C.

• The defense construction program is a matter of intimate and vital concern to the crushed stone industry and accordingly the following comprehensive analysis of the situation by Mr. Marshall should prove of real significance. Attention is particularly directed to his observations concerning the function of WPA in the defense construction field.

MR. CHAIRMAN and Members of the National Crushed Stone Association: I want to bring to you the greetings of the Associated General Contractors of America, and the hope that your convention is a successful one and will help you through the trying times ahead.

We feel that there are many questions of mutual interest between your group and the general contractors. Your market, at least a large part of it, is in construction, as is the general contractor's. Many of our operations are similar. Our labor frequently comes from the same pool. Your success is dependent largely on the success of the construction industry, and you are also faced with government competition.

I will not describe to you the nature of the A. G. C. because I think most of you are familiar with it, excepting to point out to you that there are three divisions: the Building Contractors' Division, the Highway Contractors' Division, and the Heavy Construction and Railroad Contractors' Division. We have nearly 100 chapters located in forty-six States of the nation. These chapters have local autonomy and care for local affairs, and support and assist the National Association in our national problems.

Your first interest, as is the interest of every man in America today, is in the defense program, and your second interest is in the future of our own industry. The defense program, so far as construction is concerned, is of particular interest at this time because it is in the spotlight. Construction features of the defense program necessarily come first. Therefore, construction will probably meet many of the problems that other phases of the program will encounter somewhat later.

There have been various estimates made of the volume of construction for defense. Our estimate on the appropriations thus far for pure construction is about one and a half billion dollars. About one billion dollars worth of that work has been let and is under way.

The budget presented to Congress for the coming year requests specifically only about $700,000,000 for defense construction, but the budget also states that it may have to be revised upward. We realize that more construction will be involved in the production of facilities, ships, ordnance, and so forth, for the other nations in accordance with such legislation as is now pending. We also realize that as our program progresses, there will undoubtedly be needs for construction which have not yet been fully developed. It is, therefore, our opinion that out of this program that appears before Congress today, there will probably be another billion and a half of pure construction. Thus far, then, it would be about three billion, with about one billion dollars let.

The full impact of the defense program has not hit the construction industry as yet. There is a secondary reaction in construction which is beginning to be felt in some quarters. That is, when large orders are placed with the various industries, the ordnance plants, the munitions plants, and so forth, they will splash over, eventually, into many of the smaller industries of that character, and they in turn will require certain improvements. However, in spite of what seems to be a large construction program, it appears to us that our volume will not exceed the peak reached in 1926 and '27 in normal construction.

The construction of the defense program at present is somewhat spotty. The large volume of the work has been in large, spectacular projects, located in rather new sections of the country, sections where large construction projects of that character have not been carried on in recent years. The result has been that it is necessary for labor to migrate to those locations, and some readjustment has been required in order to carry them on.

The nature of the work has been largely such that it has required a combination of constructing organ-

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izations. The War Department and the Navy, from which most of the construction work comes, have adopted a policy of securing a going organization of the contractor to do the work. They found many individual contractors with sufficient financial standing and past experience to bring together almost any type of construction organization. But they felt they did not want that. So these jobs are usually handled by a combination of a building contractor and a heavy or highway contractor which is in a position immediately to undertake the utilities and other work, as well as the building work there.

I want to point out to you here, gentlemen, that the program came upon the industry, with a bang. We feel it justifies every effort the A. G. C. has made in the past five and a half years to oppose WPA, and also the day labor activities of the various municipalities and the other units of government which tended to break down the very organizations that the Government is calling on today to speed through this program and to get it under way. Had it not been for the continuance of PWA and some of the regular construction work such as that of the Public Roads Administration through normal channels, it is probable that this industry would not have been able to respond as it has to the request of the government to carry on in this program.

Questions have been raised as to whether the industry can handle the program. There is little doubt in our mind that it can, if it has an opportunity to do so through the normal channels. There is no time now to set up new conditions that are inclined to disturb methods that have worked out satisfactorily in the industry over a long period of years.

The work consists principally of naval bases, shipyards, army posts, camps, storage depots, munition plants, ordnance plants, military air fields and bases, civilian air fields, and defense roads. The road program, there isn't any question, is of great necessity in a defense program. Surveys have been made as to some of the general requirements for the road system as a whole, for strategic purposes. Other surveys have been made with reference to access roads to these various camps, and the changes required due to the concentration of workers and people in some of these munitions plants, and so on. It was amazing to us that when the budget came through to this Congress, there was no appropriation asked for defense roads. Some people estimate the requirements eventually will be as high as one billion dollars, but they were amazed to find $995,000,000 requested for WPA. The only assumption that could be drawn was that WPA expected to be in a position to carry on that road program.

The industry has felt about WPA from the beginning that it was conceived as a relief agency. Many people in our industry have felt all along that it was the beginning of a socialization of this industry, and they have opposed it. They have seen the same principles work out in municipalities where the government undertook to do its own work. They feared government competition because of the power of government to regulate private industry, to tax it, to withhold its work from it, and at the same time provide its own agency with complete immunity from those things.

Undoubtedly there have been many fields of endeavor where WPA has done considerable good, but nevertheless, the industry has always felt that for a given dollar spent, just as much employment will be provided somewhere in this country by the regular system of carrying on public work, as through WPA. Now, it is true, it may not be exactly the same people who are employed. It is probably also true that to some degree, some of the men who were working only part-time would then be employed full-time, and therefore would not make a place for a man on WPA. But now we are faced with a situation where it appears that all of the manpower of the construction industry may be required in this program. Other industries appear to need manpower, and need it badly. It seems to us that when WPA reaches out to go into the construction of access roads and highways, in addition to all of the work they are now carrying on for the local agencies of government, the defense program has snatched the cloak of relief from them and has left them as an ambitious agency of the Government to carry on construction work.

Let us just take the situation with reference to access roads when they undertake them. The access roads will be needed, and needed very badly, very shortly. It has been our conception that WPA was to be helpful in replacing these men that they have in private employment in industry. Suppose WPA is building an access road into one of these camps and there is a shortage of men on the camp; would WPA feel that it should give its men over to that camp for that construction? No. It will naturally be placed in the position where it will have priority, where in order to carry on the work it is undertaking, it will have to keep those men. Now, these roads for defense cannot be built with relief labor solely. If they are not in a hurry for the roads—and it seems that perhaps they are not—those roads could be built

when these peak jobs are over. Remember that most of these contracts today are for construction in the large areas within ninety days or 120 days, and in the majority of them that is the limit. Then the construction organization is disbanded and workers must seek employment elsewhere.

If, in the meantime, the road program on which many of these men might have depended is taken over by an agency of the Government, these men are going to feel a good deal like the soldier feels who comes back home and finds some other guy who didn't go, has taken his job and alienated his family.

The budget message, in making its request for WPA funds, carried the thought that there was going to be unemployment in some sections; there was going to be unemployment in some skills and some crafts. There is perhaps no doubt that that is going to be true, but most of the construction today that is placing a strain upon the industry to furnish the extra men has been in the building construction, not in the highway construction, and certainly that need might be met by putting those people on the highway projects rather than have WPA come in and take them from the industry at this time.

There has been, in some communities, evidence of some cooperation from WPA in the furnishing of men, but it is our firm belief that if WPA could spend the time and the effort that it is spending with the mayors of these municipalities, to put over their pet projects; if it would spend that time, instead, trying to feed their people into this industry and other industries where they could be used, we would all get along a great deal better.

This program of defense places the construction industry in the limelight. Everyone connected with defense is going to be subject to criticism. The public is going to be critical of any difficulties. It is also going to be critical of any wasteful expenditures, because the tax is coming along now when they are going to feel it. Our industry may be criticized, and we feel that regardless of the nature of the difficulty, if we find incompetence within the industry, if we find wrong-doing, we should take it up with those branches of the industry and correct it as quickly as possible, and let us tell some of the things that the construction industry is doing. If we only had the publicity agencies that some of these Government agencies have, to tell of the marvelous things that are being done on these camps!

Many people have the notion that these cost-plus-a-fixed-fee contracts that the contractors are undertaking are very profitable. Many of them are taken at a total of less than 4 per cent, and that 4 per cent must pay the general overhead of the organization during that period. It must pay the return to the principals in that business. And it also must take care of the future social security requirements for four or five years to come where merit rating is applied in Unemployment Compensation Insurance, although we are fighting it at the present time as it applies to this industry. Also, any accident hazards that may result on those jobs naturally must be compensated for in years of future employment because the experience rating will be penalized.

We feel that every element of the industry has come to the front and is making a marvelous showing in the defense program for construction. We frequently hear labor criticized, and sometimes perhaps correctly so. Labor, of course, is working under a basic policy of trying to retain the present social gains. Naturally, in some local spots of the communities that is misunderstood. It will be understood in some places to mean that they should retain double time for all overtime, and things of that kind.

The strike situation, so far as construction is concerned, has been remarkable. There have been practically no strike delays of any serious consequence in construction since this program began. We find many projects located in sections of the country which heretofore had not experienced much dealings with organized labor. Because of the large character of the work and the necessity of getting men from the large centers of population, those projects have developed into union projects. Yet in spite of a unionization of projects in areas where heretofore unions have not existed, the labor relations have been established on those projects promptly.

If there is any thought of any value that I can leave with you gentlemen, it is that this industry is dependent on every part of it and every element and every group doing its bit in this program. We should not carry gleefully tales of some contractor's or some material man's misfortune and delay, and so forth, because that, after all, becomes a criticism of private industry, the industry that you are in. If you find something that is wrong and should be corrected in another branch of the industry, go to them and tell them about it. Give them the public reaction to it, because this industry is doing a wonderful job, and it will continue to do so, and it deserves support, and criticism only when criticism is due.

I want to say in closing that we all have the high-

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Asphalt-Stone Construction for Airport Surfaces[1]

By A. H. HINKLE

District Engineer, The Asphalt Institute, Cincinnati, Ohio

• Of increasing importance to crushed stone producers is the rapidly expanding market for crushed stone in the construction of airports as a part of the Defense Program. What Mr. Hinkle has to say in the following article with regard to airport surfaces is timely and should be of great interest.

AIRPORT surfaces should be *smooth, strong and durable, nonskid, free from loose particles,* of an *appropriate color* and of such character that they *can be repaired with ease and speed.*

An asphalt-stone mixture in one or more of its many forms can be made to comply with every one of the above requirements. A surface mix, penetration macadam course with a suitable seal, or plantmix, all have desirable features that may be used on heavy duty airports. For secondary and third class airports these types and in addition heavy surface treatments will be suitable. If a large quantity of the plantmix material is specified in one contract the price will generally not be far above the roadmix types.

(a) Smooth Surface

Due to the development of modern machinery used in building road surfaces, it is easy today to build a smooth surface of any type. Even the penetration macadam consisting of large aggregate, and which was not always built in past years with a smooth surface, is now made very satisfactory in this regard. A dragged surface treatment as a finishing course may be used to produce the necessary smoothness. Any plantmix material laid with one of the modern road pavers produces a surface as smooth as may be desired. While a smooth surface is important, it is not any longer a difficult problem with any type of road surface.

(b) Strength and Durability

The heaviest transport planes as well as heavy bombers require a heavy duty runway surface. The predicted weight of some of these proposed planes has sometimes scared us as to the strength of runway surface that might be required. However, as we learn more about them, we find such planes also have very large tires which keep the unit pressure on the runway surface to a comparatively low value. Recent English criticism of American bombers is that they have tires too small which make them difficult to get off the ground in emergencies. "They mire down too easily," reports an English representative. It is quite evident that such planes must be designed to take off in an emergency in places other than at a highly developed airport.

It is doubtful if our airport runways will ever be called upon to carry as heavy unit loads as are carried by some of our heavy duty highways. Certainly this will be true of most airports. As the airplane increases in weight the larger will be the tires. The best information would seem to indicate that airport runways will somewhat parallel our highways for strength requirements and that generally good practice followed in highway design will apply to airport runways. Hence, it would seem that the problem of designing airport surfaces is little different than that of designing highways except for some drainage problems due to runways being so much wider than highways.

I do not want to burden you with all the details of these designs as they are generally well known. However, a few comments on the macadam type of base and asphalt surface will be made.

Subgrade

Good highway design of today gives first consideration to the subgrade. The bearing power of the subgrade of some soils can be immensely increased by proper compaction. Many comparatively light surface roads have shown signs of failure earlier than they would have shown had the density of such soil been greater. Compaction of subgrades can be

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economically made for 5" to 7" in thickness with a sheep's foot roller with optimum moisture content in the soil. Where cheap aggregates are available whether they be bank run gravel, waste product from the quarry or other aggregate material, a layer of same perhaps partially mixed and compacted with the subsoil will greatly reduce the required thickness of pavement.

The waterbound macadam base is still a very economical design. The art of building a good waterbound macadam course is not always understood by some of our younger engineers. However, due to its economy in many places and the fact that frequently in an emergency loose stone must be piled on a raw subgrade, it is believed that every highway engineer should acquaint himself with the best practice in compacting the stone. Even where gravel base courses are constructed, to secure quick compaction, it will be desirable to use some limestone screenings rather than too much clay which may become a source of weakness. Limestone screenings can be used in so many different ways in connection with building a road that it is doubtful whether the best practice has been followed by the engineers and stone producers when large excess of this material is found at many of our quarries. Possibly the engineers have failed to recognize its value or the stone producer has not been sufficiently reasonable in his price.

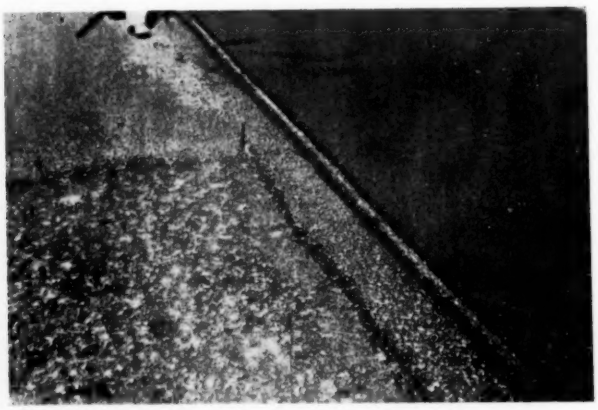

FIG. 1. WATERBOUND MACADAM BASE, 2" HOT MIX ASPHALTIC CONCRETE BINDER AND 1½" HOT MIX ASPHALTIC CONCRETE WEARING SURFACE.

Not many weeks ago a macadam drive was observed around one of our new defense projects wherein coarse stone had been filled with cinders as fine material in the wearing surface. There perhaps is no better aggregate for mopping up the muddy subgrade than cinders but its abrasion value is almost zero and hence it should not be used in the surface. In this case had the cinders been placed on the raw subgrade before macadam was placed and limestone screenings used for a filler, it would have been a much more appropriate design.

DIFFERENT TYPES OF TOP SURFACE

With a base sufficiently strong, a top surface may be constructed of penetration macadam, roadmix or a bituminous concrete plantmix. Some places a roadmix or penetration macadam binder course has been used and a plantmix wearing surface constructed. This is very good design. However, *if great speed is required* hot plantmix in both binder and top course, may be preferable. A hot plantmix course can be constructed one day and used the next. With a roadmix and penetration type the time element and weather are factors which must be offset against possibly lower cost.

The hot plantmix material has so many good qualities that it is now used as a base course, as well as a binder and top course. Its use as a base is increasing. No doubt it will be used much more extensively in the future than in the past. When large contracts are awarded for this type the price is usually greatly reduced. It is believed by those who have been studying the subject that the thickness of hot plantmix base may be about half the thickness of the waterbound macadam and two-thirds the thickness of a penetration macadam in order to secure an equal stability. Underneath the bituminous concrete plantmix base course should be a layer of limestone screenings or other fine aggregate one or more inches in thickness to insulate same against the subsoil. A good design frequently used provides several inches of waterbound macadam or other form of stabilized aggregate as a first course on plastic clay soils.

In the hot plantmix used on airport runways, a softer asphalt (generally 120-150 penetration) should be used than is ordinarily used in highway pavements. This is desirable because of the much lighter traffic on the runways. Parts of many of the runways on second and third class airports receive very little traffic. For this same reason it is desirable that a dense mixture be used.

(c) Non-Skid Surfaces

While a non-skid surface on airports is required, this requirement is no more important on airport runways than on our highways. Due to much less

use of the runways than the main highways the development of a "slick" surface from wear is unknown. Asphaltic mixtures of which stone is frequently the major constituent, have proven among the highest of the non-skid surfaces. The very thorough research work carried on by the Engineering Experiment Station of Iowa State College and reported in December 1933 Proceedings of the National Research Council by Professor R. A. Moyer is enlightening on this subject.

While we know the nature of aggregate in the mix is a governing factor of the non-skid character of the surface, no runways up to this time have sufficient traffic to produce other than entirely non-skid surfaces. Hence, we might conclude that while this feature is one that may be given consideration there is little reason to feel it is a serious one at this time. Should a runway surface perchance become too smooth from one cause or another, a surface treatment of heavy cutback asphalt or soft asphalt cement with appropriate covering aggregate can be used to correct such condition as described under (f).

(d) Freedom from Loose Particles

If a plantmix of reasonably dense grading is used, no loose stone will be found on the surface. If a roadmix or penetration type of surface be constructed, the last treatment should be a seal of soft

FIG. 2. LIGHT COLORED SURFACE ON TWO CENTER LANES PRODUCED WITH 20 LBS. AGGREGATE COVERING ON 0.2 GAL. OF MC-5 CUTBACK ASPHALT PER SQ. YD.

asphalt cement or a heavy cutback such as the RC-5 or MC-5 grade. With such treatments which are described under (f) below, loose particles on the road surface are prevented.

(e) Color

Much has been said about the desired color of an airport surface. A light colored surface may be more visible than a dark colored surface. However, the author has never yet read of an accident on an airport runway that was attributed to the dark color

FIG. 3. STATE ROAD NO. 67 BETWEEN INDIANAPOLIS AND FORT BENJAMIN HARRISON. TWO CENTER LANES OF HOT MIX ASPHALTIC CONCRETE ARE AS WHITE AS THE TWO P. C. CONCRETE SIDE LANES.

of its surface. Let this be as it may, it is most certain that in time of war the dark colored airport surface would be less conspicuous to the enemy either for photographing or dropping bombs. We might conclude a surface that can be changed from a light color to dark, or vice-versa is preferable. The hot mix bituminous concrete produces a black surface when first constructed. If desired the surface can be at once changed into a light color. The surface can be made white by a surface treatment with soft asphalt cement, perhaps 120-150 penetration, or RC-5 or MC-5 cutback asphalt; covered with a white aggregate well rolled into the hot asphalt. If at any time it is desired to re-blacken a white surface a "fog treatment" of a diluted asphalt emulsion can be used for same.

(f) Speed and Ease of Repair

A very necessary requirement for airport runways is a surface that can be easily and speedily repaired so that there will be the least interference to the runways' use. Here again two classes of resurfacing material seem to stand out as best meeting this requirement. The first is the hot mix asphaltic concrete. Such a resurfacing can be laid 1″ to 2″ in thickness as may be required to level the surface or

increase its strength, and as soon as laid and rolled it may be used. Also if only a part of a runway is surfaced when it is required for use, the little offset of 1″ or 2″ in thickness parallel with the line of traffic would not be serious. Hence, resurfacing operations might be carried on part of the day and the runways used the remaining portion. Such a surface is laid very rapidly with one or more of the modern road pavers.

If only a light seal coat is required on a runway, a treatment of soft asphalt cement, or RC-5 or MC-5 cutback asphalt, with covering aggregate promptly rolled into it, is most satisfactory (the RC-5 being a quicker drying asphalt would be preferable in hot weather if great speed is important). This may be used to produce the desired white surface as described in paragraph (e).

In such surface treatments it is important to use small sized aggregate so as to prevent loose particles being blown about. If the surface is already tightly sealed no more than 0.2 gal. of asphalt per square yard should be used. If an open surface, perhaps 0.25 gal. is the maximum. The aggregate covering should be a maximum of ⅜″ size of rather uniform grading. Smaller size will bury itself in the asphalt and thus

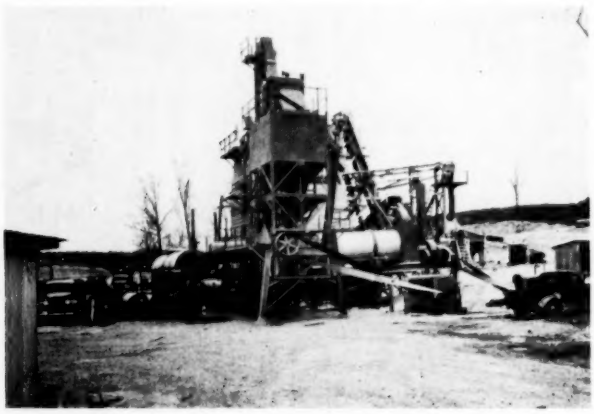

FIG. 4. SEMI-PORTABLE MODERN HOT MIX BITUMINOUS CONCRETE PLANT. TURNS OUT GOOD HOT MIX AT RAPID RATE.

not leave a white surface. Also the fines would interfere with the larger size aggregates properly imbedding themselves in the asphalt for maximum cementation. Thus it will be seen that such treatments can be used not only to preserve the surface and seal it against disintegration, but also to produce a white color if desired.

If repairs are needed at any time pre-mix is most satisfactory. For repairing small holes a suitable sized aggregate might be coated with the hot MC-5 cutback asphalt and the mixture allowed to stand in stock-pile a short while until it becomes sufficiently tacky to readily stay in the hole when tamped. In cool weather this would be immediately after it was mixed. In hottest of summer weather such mixture might be permitted to stand a number of days or even weeks and still be suitable for patching material.

Other Available Types

While I have spoken of several suitable types of surface appropriate for heavy duty runways, including roadmix, penetration macadam and hot plantmix bituminous concrete and have laid emphasis upon the latter as perhaps filling more of the requirements for the finished surface than any other type, there are other asphalt types which have been used very successfully and are quite satisfactory. The availability of the materials and different plant mixtures may be a governing factor in selecting the type to use on an airport as well as on a highway.

The airport at Morgantown, West Virginia constructed by WPA has a base constructed of local sandstone. On this was constructed a plantmix consisting of limestone screenings and RC-2 grade of cut back asphalt mixed in a concrete mixer. I believe Mr. Miller who is to discuss this paper will describe the details of this project and hence I will not comment further on its method of construction. The runway surfaces made of this mixture are in most excellent condition. This was a case of taking advantage of the local material and it only illustrates again that generally speaking there should not be large piles of waste product around our various quarries.

The Cleveland Municipal Airport consists of 5″ waterbound slag base, 2″ asphalt penetration macadam binder course and 1½″ cold laid asphaltic concrete of the amiesite type as a wearing surface. This was given a seal coat. This airport carries very heavy traffic and handles the largest transcontinental planes. It will be observed that the total thickness is not very great,—only 8½″, on a soil that is certainly none too stable. However, should heavy planes distort the surface sufficiently to produce any roughness, a 1½″ to 2″ thickness of new bituminous concrete of hot mix type would again put it in perfect condition. This work could be done with no great interference with traffic by taking advantage of the changing wind direction. A partially surfaced runway could

(*Continued on page 17*)

Bituminous Concrete of Crushed Stone Screenings and Asphalt Used in Wearing Course Construction Morgantown, West Virginia, Municipal Airport[1]

By A. M. MILLER

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• **Appropriately supplementing the article by Mr. Hinkle, given elsewhere in this issue, Mr. Miller presents in the following discussion the highly interesting construction details of the municipal airport built at Morgantown, West Virginia.**

CONSTRUCTION on the Municipal Airport, a WPA project at Morgantown, West Virginia, was started in 1935. Estimated cost of the completed airport, which cost includes three runways—3600, 3200 and 3100 feet in length; entrance drive—2250 feet; hangars, administration buildings and park, was $1,500,000.

The airport is located approximately two miles northeast of Morgantown and one-quarter mile from U. S. highway No. 119.

Drainage facilities are excellent inasmuch as the airport is located on a high, narrow ridge. The elevation is 1250 feet. The sub-base is in the geologic formation known as the Upper-Pittsburgh sandstone which lies approximately horizontal at this location.

The total excavation required in leveling the surface for the runways was approximately 913,000 cubic yards of which 500,000 cubic yards was sandstone. The base course for the runways and building stone for the structures was obtained from the excavated material.

The base course for the runways and for the roadway leading to the airport was constructed of knapped stone placed in two six-inch layers making a total thickness of twelve inches. Each layer was thoroughly rolled with a ten-ton, three-wheeled roller. The top course was then choked with limestone screenings—grading ⅜" to dust. The average cost of constructing the base course was $4.60 per cubic yard or $1.53 per square yard.

The type and thickness of the wearing surface selected was influenced by three factors: limited funds for materials; the use of a minimum amount of equipment and the maximum amount of labor; and the fact that certain gradations of limestone were available at low cost from a local commercial quarry.

The Department of Tests of the West Virginia State Road Commission, after investigating the above factors, suggested the construction of a bituminous premix surface, two course construction, using cut-back asphalt. Samples of the limestone aggregates and asphalt cut-back, MC and RC materials, were secured by the laboratory for test purposes. The type and amount of asphalt cut-back to be used with each course was determined experimentally by use of the Hubbard-Field Stability Machine and the Kriege-Mimmi Wheel Apparatus.

The two aggregates available were West Virginia #7 and #13.

Average gradations:

Size #13 (Wet Screening)		Size #7	
Passing ⅜" sieve	100.0%	Passing 1" sieve	100.0%
" #4 "	97.2	" ¾" "	97.9
" #10 "	50.9	" ½" "	65.4
" #20 "	23.5	" ⅜" "	23.9
" #30 "	19.7	" #4 "	1.8
" #40 "	17.5		
" #50 "	15.5		
" #80 "	13.5		
" #100 "	12.7		
" #200 "	10.8		

It was believed in the beginning of the experimental work that it would be necessary to use a kerosene cut-back with a viscosity near that of MC-2 or MC-3 due to the high dust content of the #13 stone. Trial mixes made in a Blystone mixer, however, demonstrated the fact that RC grade asphalt might be used successfully with the #13 as well as the #7 stone. RC material was therefore used in the experimental work.

[1] Presented at the Twenty-Fourth Annual Convention of the National Crushed Stone Association held at the Netherland Plaza Hotel, Cincinnati, Ohio, January 20-22, 1941.

Analysis of bituminous materials including MC-1 which was used for prime coat:

	MC-1	RC-2	RC-3
Specific gravity, 15.5°C./15.5°C.	.929	.960	.964
Furol viscosity, 77°F.	126		
Furol viscosity, 122°F.		236	
Furol viscosity, 140°F.			358

Separation of asphalt base from Distillate Flux:
Fractions (% by volume)

	MC-1	RC-2	RC-3
0–320°F.	0.0	1.0	0.0
0–374°F.	0.0	7.0	3.5
0–437°F.	3.0	16.5	11.0
0–600°F.	33.5	24.0	18.0
0–680°F.	42.0	25.5	20.5

Characteristics of residue from distillation to 680°F.

Penetration 25°C., 100 grams, 5 seconds	255	108	105
Bitumen Soluble in CS_2 (per cent)	99.9	99.9	99.9

Results of Hubbard-Field test on limestone sand-asphalt mix. Shearing strength of 2" diameter x 1" thick briquettes. Testing temperature—80°F.

% RC-2 Asphalt	Hubbard-Field Stability—pounds
6.0	4200
8.0	5800
10.0	4450
12.0	3500
Control sample	3400

Note: "Control sample" made from material that had given excellent service in the field.

Base—#7 stone, RC-3 asphalt 4.5% thickness 0.93"
Top—limestone sand, RC-2 asphalt 9% thickness 0.41"

Total thickness 1.34"

Two samples tested:

#1 test failed in position #35 at 75°F.
#2 test failed in position #33 at 75°F.

One other sample using RC-3 in the top and bottom course was tested. Failure occurred in the 34th position at 75°F.

All samples were cured in an oven for 72 hours at 150°F. and then 25 days at room temperature.

The above test results indicate a high strength as compared with other materials of known performance.

Three important requirements for runway surfacing were in mind during the experimental work: a high bitumen content must be maintained as the kneading action of traffic is negligible; the surface must be relatively skid-proof and stable.

The final mixes suggested by the laboratory were as follows:

Binder Course:
.43 gallons of RC-3 per cubic foot of stone
Weight of stone—90.7 lbs/cu. ft.—loose
Bitumen Soluble in CS_2; per cent of dry stone—3.25

Top of Wearing Course
1.14 gallons of RC-2 per cubic foot of stone
Weight of stone—100 lbs./cu. ft.—loose
Bitumen Soluble in CS_2; per cent of dry stone—7.3

FIG. 1. PORTABLE MIXING PLANT USED ON A PORTION OF THE WORK.

Due to the variation in the fine content of the limestone sand, the quantity of RC-2 was increased or decreased in proportion to the increase or decrease in the 100 mesh material. The maximum number of gallons per cubic foot of stone was approximately 1.3.

Construction Procedure

Mixing and placing the surfacing material was let to contract. The contractor furnished the bituminous material, mixing plant, bituminous paver, distributor and skilled labor while the city supplied the necessary trucks, rollers, limestone aggregate and common labor. The contract price was 9 cents per gallon for RC-2 and 14 cents per gallon for RC-3. The bid prices on the RC-2 and RC-3 included mixing and placing.

A 27-E Multi-Foote paver was used by the contractor for mixing the asphalt and stone for the first two runways. The mixer was so located that the aggregate trucks could back up a short ramp, discharge the aggregate into a bin from which it was

fed by gravity into a calibrated hopper and thence directly into the mixer drum. The asphalt was delivered to the job in a distributor truck and stored in a 500 gallon capacity tank erected beside the ramp. A three-inch pipe line fed the asphalt by gravity to an oil drum which was equipped with a hook gauge for volumetric measurement, and thence directly to the mixer drum. The mixer discharged directly into the empty trucks.

FIG. 2. SPREADING THE BASE COURSE MIXTURE ON THE STONE FOUNDATION.

Surface dried stone was specified for the mix. Drying was accomplished by spreading the damp material over the runway surface and then manipulating by blade, drag and hand shovels until the fine aggregate was dried to the satisfaction of the inspector.

High moisture content resulted in some balling of the #13 stone. This condition was easily corrected by placing a ½" square mesh sieve in the storage bin. The trucks discharged the aggregate onto the sieve on which the material was then manipulated by rakes until it was pulverized sufficiently to pass the ½" opening.

Thirty-one cubic feet of stone and 11.5 gallons of RC-3 were mixed in each batch of binder course; the mixing time was ½ minute. Twenty-one and one-half cubic feet of stone and 24.5 gallons of RC-2 were mixed in each batch of wearing course; the mixing time was approximately 1½ minutes.

A Barber-Greene continuous type pug mill mixer was used for mixing the asphalt and stone for the third runway. The plant set-up was somewhat similar to that used with the Multi-Foote paver. The aggregate, in this case however, was measured volumetrically as it passed on a belt conveyor through a calibrated gate and the asphalt was measured by volume with a metering device that was synchronized with the aggregate conveyor. The mixture from the Barber-Greene was uniform in texture, contained practically no uncoated particles or fat spots. The Barber-Greene mixed approximately two tons of binder stone per minute and one ton of wearing course.

Two ¼ gallon applications of MC-1 prime coat were applied to the stone base three days before the binder course was laid.

A Jaeger paver was used in spreading the two courses on the first two runways and a Barber-Greene paver was used on the third runway; 125 pounds per square yard of binder course and 78

FIG. 3. REAR VIEW OF SPREADER LAYING THE STONE SAND—RC-2 CUTBACK ASPHALT MIXTURE SURFACE COURSE.

pounds per square yard of top course. This resulted in a compacted thickness of approximately 1⅛ inches binder and ⅝ inch top course.

A three-wheeled ten-ton roller was used for initial and final compaction. Only longitudinal rolling was required.

A top dressing of 5 pounds of #13 stone was broomed into the surface voids. This material acted as a seal and whitened the surface considerably.

Maximum tonnage of binder course produced in 1 day	400
Maximum tonnage of top course produced in 1 day	250

Approximate Costs Per Square Yard

Common labor, trucks and drivers, supervision, inspection and roller costs were about the same for the construction of both the top and binder courses which was approximately .081 cents per square yard.

Top Course:	
Labor, etc.	0.081
Asphalt—.813 gals. at 14 cents	0.114
Aggregate—(mix and seal)	0.057
Total Cost of Top	0.252
Binder Course:	
Labor, etc.	0.081
Asphalt—5.28 gals. at 12 cents	0.063
Aggregate	0.122
Total Cost of Binder	0.266
Prime Coat:	
Asphalt 0.5 gals. at 9 cents	0.045
Total Cost of Bituminous Surface	$0.57
Total Cost of Stone Base	1.53
Total Cost of Runway, base and surface course	2.10

The finished surface of "A" runway which was laid in 1937 has been tested by heavy transport planes and army planes. Heavy trucks have been hauling over this surface since its construction. No shoving, cracking, distortion or raveling is evident. The surface presents a non-skid texture or sandy finish. The surface is practically waterproof as determined by the permeability test.

Contractors and National Defense

(*Continued from page 8*)

est regard for Mr. Fellows and many other high-grade men in WPA all the way through. We think it is a mistaken philosophy. We think it is a mistake at the present time, and we would like, if we can, to help them off the spot that we think they are on, of trying to convert a relief agency where the maximum motive was to produce employment to meet an employment condition, into an agency where the motive must be the greatest production with the greatest conservation of manpower, equipment and materials.

National Defense and the WPA

(*Continued from page 5*)

processed on the project. And so the work of producing or processing these materials falls on the WPA and is counted as a part of the WPA's labor costs. This reduction in non-labor cost is very often the deciding factor in determining whether a project can be placed in operation.

In producing aggregate and in mixing concrete, the WPA is following a generally accepted practice of private contractors and State and county highway departments throughout the country. The practice is one which has been shown by long years of experience to be efficient and economical for construction work, and it applies to force account operations as well as, if not better than, to private contract work.

It has been suggested that while production activities of this kind are sometimes essential to the creation of employment, they may be in competition with private industry. It is evident, however, that so long as the products of WPA activities are confined to the projects and are not placed in competition with commercial products in a common market, there can be no real competition between the two. Commercial products are purchased wherever possible; WPA production activities are carried on only where commercial products are not easily or reasonably obtainable or where the operation of certian projects is dependent upon the production of materials within the projects.

I have described WPA production activities in as clear-cut a way as possible, so as to get down to the central issue. In practice, the issue is seldom clear-cut, since in practice even the production of certain materials involves the purchase of other materials.

During the last fiscal year, for example, over $82,000,000 was spent in purchasing cement, and aggregate materials, including crushed stone, as well as ready-mixed concreate and concrete products, for WPA projects. Of this total, well over $17,000,000 was expended for crushed stone.

And finally, by way of illustration, let us see what happened last year in the State of Ohio. WPA purchases of stone and slag in Ohio during 1940

amounted to $1,156,000, while the WPA here produced limestone valued at $237,000, or only about one-fifth as much.

I have digressed from my main topic in order to speak in some detail about the WPA's production activities, because I realize that you are particularly interested in that phase of the WPA program. But now I should like to stand back again and take a final look at the WPA picture as a whole.

The manufacture of war materials in this country —including the preliminary building of factories and the making of tools and machinery—already constitutes a much larger field of defense employment than that occupied by the WPA. This field of private defense employment will become still larger, month by month during 1941. And yet the defense industries can be expected to draw only a very small proportion of their new employees from the ranks of the WPA, because a majority of WPA workers are unskilled or over the age approved by private industry. It is gratifying to observe the extent to which private defense work is lifting the burden of unemployment in many places throughout the country. But it is a serious mistake to exaggerate the effect which this will have upon unemployment in general and upon the WPA program. As fast as our unemployed can get jobs in the defense industries, or in private industry of any kind at standard wages, they are doing so, and they will continue to do so. In the meantime, however, wherever unemployment still exists, the nation still has a responsibility toward the unemployed. And in return there are many valuable services which the unemployed can perform for the nation.

WPA workers were doing good work in behalf of our national defense long before we recognized how important that work was. They are still working for national defense, and they will continue to do so, in my opinion, so long as there is public defense work to be done and unemployed workers to do it.

Asphalt-Stone Construction for Airport Surfaces

(*Continued from page 12*)

be used promptly after the spreading machinery and roller were removed. The great advantage of asphalt for stage construction is an important item to consider, and provides for future growth of an airport.

The Columbus, Ohio, Airport, built a number of years ago, generally consists of 6″ concrete base and 1½″ hot mix bituminous concrete top. This airport has given very satisfactory service. Here again the cracking and any signs of weakness that have developed can be corrected with 1½″ or 2″ of new bituminous concrete and the surface will then be a stronger one than when first constructed.

I might go on and enumerate an endless number of cases of most satisfactory airports made of asphalt and stone. In a few cases too light a course for the soil conditions has been constructed on airport runways and failures have resulted. In one instance, a 6″ waterbound macadam surface was constructed on poorly drained unstable soil, without any drainage installations beneath the surface. With such soil conditions this surface would have heaved without any traffic. The 6″ of macadam was only a base course. Four inches to six inches of bituminous concrete with some additional drainage provisions would have made it one of the finest airport surfaces in the country. It was a waste of funds to destroy this surface and construct an entirely new pavement, because of faulty engineering in the first instance.

In contrast, on another airport 5″ macadam has been constructed on the runways. There is under consideration a resurfacing with plantmix asphaltic concrete. There is being considered a wedge course of bituminous concrete 2½″ thick, at the center and zero at the edge to increase the too flat crown and on this one or more courses with a total thickness of 2″ to 4″ to secure the required strength. This airport is in good engineering hands and it is predicted no funds will be wasted in developing whatever strength of pavement is required.

That many miles of our old roads with macadam type of base have given service for 20, 30 and 40 years with suitable resurfacings having been constructed to take care of the increased loads from our heavy trucking, is proof that this type of base is well worth our careful study in designing airports as well as highways. As new types of pavement attract our attention we sometimes forget about the older types which have proved themselves beyond a doubt. During the first World War an Army Officer was asked the question what type of pavement was most suitable for military highways. He thought a moment and stated, "A macadam road 3 feet thick." It was understood by all those present that he did not exactly mean this literally but what he meant was a macadam or flexible type of road with sufficient thickness to carry the load.

In closing, let me state that we must take advantage of our local materials whether they be slag,

gravel, stone or what not. That good stone has made a place for itself in highway building is quite evident and it no doubt will maintain that place, not only in the base course, but also when properly bonded with asphalt in the top courses as well. Also the bituminous concrete is being used each year to a greater extent in the base of the flexible type of road. What is said of highways applies equally well to airport surfaces for they are merely pavements in a different location from where we have been accustomed to build them.

"Highway Mail Coach" is Success

UNCLE SAM'S first "highway mail coach" is a success. This new service, which marks one of the most significant developments in mail transportation, has been operating for a month over a 140 mile route between Washington, D. C. and Harrisonburg, Virginia. Now two more trial routes are to be established in other sections of the country.

Operated on the same basis as the railway mail service, the mails are carried on large bus-type trucks completely equipped with all facilities for sorting, handling and dispatch that are included in railway postal cars. As more are put into use, they will provide increased and faster mail service to those areas formerly served by short line and feeder railroads. During the past few years, Postmaster General Walker pointed out, many railroad companies have been forced to discontinue non-profitable passenger trains on lines which formerly utilized large numbers of railway postal cars.

As a result, the Post Office Department was forced to establish motorized star route service which has only partially supplied the facilities previously enjoyed by postal patrons when railway postal cars were in operation. This contract operation of motor truck star routes also failed in many instances to provide adequate service in the exchange of mails at intermediate points.

Now comes the highway mail coach which will perform the same general services on shorter runs between smaller cities and towns and the importance of these new coaches can be realized when it is considered that 48,000 communities of the United States are entirely without rail service. These towns are important and their requirements are extensive. The experimental highway post office indicates the general trend toward better service for such communities.—*Highway Highlights.*

Access Roads Come First in Nation's Defense Program

FIRST roads to be built in the national defense program will be those leading into and approaching army reservations and industrial sites, according to John M. Carmody, Federal Works Administrator. He estimates that approximately 4,000 miles of such access roads are essential to take care of present plans for 175 camps and industrial sites that have been certified for defense highways. This construction will cost about $230,000,000.

Some of these urgently needed roads are being built, he added, particularly within the reservations, but other access roads are being delayed because funds are not available; for by law, present Federal-aid appropriations can be spent on the construction of access roads only if state or local money is available to pay part of the cost, and some states, he said, do not have the money required.

The 75,000 miles of long distance routes designated as the nation's strategic network can, he declared, be brought up to standard at a fairly reasonable cost. This, he emphasized, will be steadily done under the Federal-aid program, but he added, "It is not in the best interests of the nation to demand immediate construction of very expensive improvements on the strategic network in the guise of national defense."

War Department Makes First Test Over Arkansas Highways

THE first complete highway movement of troops as a combat unit in cooperation with commercial motor vehicles was successfully carried out in Arkansas.

At the War Department's request, 1,900 officers and men were transported to Little Rock from 15 points within the state. In carrying out this tactical problem of determining the role of bus and truck operators in the transportation of combat units a total of 21 buses and 56 trucks in addition to regular army vehicles was used. The longest haul was 220 miles. The entire 153rd Infantry, Arkansas National Guard, arrived at their destination ready to go into action. The movement demonstrated that widely separated units could proceed to a center in much shorter time than has been possible to do in the past.

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Gruendler Crusher and Pulverizer Co.
2915 N. Market St., St. Louis, Mo.
Rock and Gravel Crushing and Screening Plants, Jaw Crushers, Roll Crushers, Hammer Mills, Lime Pulverizers

Hardinge Co., Inc.
York, Pa.
Scrubbers, Pulverizers, Dryers, Feeders, Classifiers, Washers, Thickeners

HarriSteel Products Co.
420 Lexington Avenue, New York, N. Y.
Woven Wire Screen Cloth and Abrasion Resisting Products

Hayward Co.
50 Church Street, New York City
Orange Peel Buckets, Clam Shell Buckets, Drag Line Buckets, Electric Motor Buckets, Automatic Take-up Reels

Hendrick Mfg. Co.
Carbondale, Pa.
Perforated Metal Screens, Perforated Plates for Vibrating and Shaking Screens, Elevator Buckets, Hendrick Vibrating Screens

Hercules Powder Co.
Wilmington, Del.
Explosives and Blasting Supplies

Illinois Powder Mfg. Co.
124 N. 4th St., St. Louis, Mo.
Gold Medal Explosives

Iowa Manufacturing Co.
Cedar Rapids, Iowa
Rock and Gravel Crushing, Screening, Conveying and Washing Plants, Hot and Cold Mix Asphalt Plants, Stabilizer Plants, KU-BIT Impact Breakers, Screens, Elevators, Conveyors, Portable and Stationary Equipment.

Kennedy-Van Saun Mfg. and Eng. Corp.
2 Park Ave., New York City
Material Handling Machinery—Crushers, Pulverizers, Vibrating Screens

Kensington Steel Co.
505 Kensington Ave., Chicago, Ill.
Manganese Steel Castings, Dipper Teeth, Crawler Treads, Jaw Plates, Concaves and Hammers

The King Powder Co., Inc.
Cincinnati, Ohio

Koehring Co.
3026 W. Concordia Ave., Milwaukee, Wis.
Mixers, Pavers, Shovels, Cranes, Draglines, Dumptors, Traildumps, Mud-Jacks

Kraft Bag Corporation
630 Fifth Ave., New York City
Multi-Wall and Heavy-Duty Paper Sacks, both Valve and Openmouth

Lima Locomotive Works, Inc.
Shovel and Crane Division
1108 Lima Trust Bldg., Lima, Ohio
Power Shovels, Draglines and Cranes

Link-Belt Co.
300 West Pershing Road, Chicago, Ill.
Complete Stone Preparation Plants. Conveyors, Elevators, Screens, Washing Equipment, Speed-o-Matic Shovels—Cranes—Draglines and Power Transmission Equipment

Ludlow-Saylor Wire Co.
Newstead Ave. & Wabash R. R., St. Louis, Mo.
Woven Wire Screens and Wire Cloth of Super-Loy, Manga-Loy and all commercial alloys and metals

Marion Steam Shovel Co.
Marion, Ohio
A Complete Line of Power Shovels, Draglines and Cranes

MANUFACTURERS' DIVISION of the NATIONAL CRUSHED STONE ASSOCIATION

McLanahan & Stone Corp.
Hollidaysburg, Pa.

The National Supply Co. of Delaware, Superior Engine Division
1401 Sheridan Ave., Springfield, Ohio
Diesel Engine Equipment

Nordberg Mfg. Co.
Milwaukee, Wis.
Cone Crushers, Vibrating Screens, Diesel Engines, Steam Engines, Compressors, Mine Hoists, Underground Shovels, Track Maintenance Tools

Northern Blower Co.
65th St. South of Denison, Cleveland, Ohio
Dust Collecting Systems, Fans—Exhaust and Blowers

Northwest Engineering Co.
28 E. Jackson Blvd., Chicago, Ill.

The Osgood Company
Marion, Ohio
Power Shovels, Draglines, Cranes

Parsons Engineering Corp.
3599 E. 82d St., Cleveland, Ohio
Dust Collecting Systems: Fans, Hoods and Blow Piping

Pioneer Engineering Works, Inc.
1515 Central Avenue, Minneapolis, Minn.
Jaw and Roll Crushers, Vibrating and Revolving Screens, Scrubbers, Belt Conveyors, Traveling Grizzley Feeder

Pit and Quarry Publications
538 South Clark St., Chicago, Ill.
Pit and Quarry, Pit and Quarry Handbook, Pit and Quarry Directory, Concrete Manufacturer, Concrete Industries Yearbook

Robins Conveying Belt Co.
Passaic, N. J.
Belt Conveyors, Bucket Elevators, Gyrex and Vibrex Screens, Feeders, Design and Construction of Complete Plants

Rock Products
309 West Jackson Blvd., Chicago, Ill.

Ross Screen and Feeder Co.
19 Rector St., New York City
Ross Patent Chain Feeders for Feed Control of All Sizes Rock, Ores, Gravel, etc.

Screen Equipment Co.
9 Lafayette Ave., Buffalo, N. Y.
SECO Vibrating Screens

Simplicity Engineering Co.
Durand, Mich.
Simplicity Gyrating Screen, Simplicity D'centegrator, Simplicity D'watering Wheel

Smith Engineering Works
E. Capitol Drive at N. Holton Ave.,
Milwaukee, Wis.
Gyratory, Gyrasphere, Jaw and Roll Crushers, Vibrating and Rotary Screens, Gravel Washing and Sand Settling Equipment, Elevators and Conveyors, Feeders, Bin Gates, and Portable Crushing and Screening Plants

Stephens-Adamson Mfg. Co.
Aurora, Illinois
Complete Stone Preparation Plants, Conveying, Elevating, Screening, Transmission Equipment

W. O. & M. W. Talcott, Inc.
91 Sabin St., Providence, R. I.
Belt Fasteners, Belt Lacing, Conveyor Belt Fasteners, and Patch Fasteners

Taylor-Wharton Iron & Steel Co.
High Bridge, N. J.
Manganese and other Special Alloy Steel Castings

The Texas Co.
135 E. 42nd St., New York City

The Thew Shovel Co.
Lorain, Ohio
Power Shovels, Cranes, Crawler Cranes, Locomotive Cranes, Draglines. Diesel Electric, Gasoline. 3/8 to 2-1/2 cu. yd. capacities

The Traylor Engineering & Mfg. Co.
Allentown, Pa.
Stone Crushing, Gravel, Lime and Cement Machinery

Trojan Powder Co.
17 N. 7th St., Allentown, Pa.
Explosives and Blasting Supplies

The W. S. Tyler Co.
3615 Superior Ave., N. E., Cleveland, Ohio
Wire Screens, Screening Machinery, Scrubbers, Testing Sieves and Dryers

Warren Brothers Roads Co.
38 Memorial Drive, Cambridge, Mass.
Complete plants and separate plant units for bituminizing all types of stone, sand and gravel aggregate paving mixtures

Westinghouse Electric & Mfg. Co.
East Pittsburgh, Pa.
Electric Motors and Control